PATENT SPECIFICATION

709,431

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COMPLETE SPECIFICATION

Improvements relating to the Testing of Gear Teeth

We, CECIL REGINALD BURCH, of 11, Percival Road, Clifton, Bristol, 8, in the County of Gloucester, and JAMES MORRISS BURCH, of 27, Elmgrove Road, Cotham, Bristol, 6, in the County of Gloucester, both British subjects, and METROPOLITAN-VICKERS ELECTRICAL COMPANY LIMITED, of St. Paul's Corner, 1—3, St. Pauls Churchyard, London, E.C.4, a British Company, do hereby declare the invention, for which we pray that a patent, may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

In copending Patent Application No. 14,142 of 1949 (Serial No. 673,971) there is described a method of testing the accuracy of the surface of a screw thread in which the surface, as viewed by reflection or refraction from a special auxiliary surface, is compared with a standard reference surface of an interferometer so that any departure of the screw surface from the desired configuration will be revealed by the production of light fringe patterns. According to this copending Application such comparison is effected by an adaptation of the Michelson interferometer in which the screw thread to be tested is arranged in substitution for one of the usual plane test surfaces with its axis parallel to the instrument axis, and the surface of the thread is viewed by reflection from the auxiliary surface which is itself generally screw shaped in form and is so shaped and arranged that the surface of the screw as seen by the instrument appears substantially plane and may thus be compared with the other plane test surface of the interferomeer.

The present invention is concerned with an adaptation of the above method to testing the accuracy of the shape of gear teeth which are of involute form.

The present invention provides a method of testing the accuracy of a profile surface of a straight- or helical-cut gear in which the gear is set up in a Michelson type interferometer in substitution for one of the two usual plane test surfaces and with its axis parallel to the optical axis, and the surface of the gear is viewed by reflection from an auxiliary surface which is itself of the same general shape as the gear profile surface and is so shaped and disposed as to produce a subsantially plane image of the gear surface which can be compared with a standard, plane reference surface of the interferometer.

By a "plane image" is meant not necessarily an image stigmatic in the Gaussian sense but an image characterised in that the transit time measured along a principal ray, or a ray paraxial thereto, is that which it would be were the combination according to the invention replaced by a plane surface.

The formation of such a plane image requires that every ray along the axis after incidence upon the auxiliary surface should be reflected along a normal to the tooth surface, and this further requires that for every pair of corresponding points on the auxiliary surface and the tooth surface the angles of steepest descent (β) must be half at the former surface what it is at the latter and that the normals must coincide as viewed in plan, or, in other words, must both miss the axis by the same skew distance (δ).

Now the geometry of the involute curve implies that both δ and β are constant over the whole tooth surface of any spur or helical gear. The skew distance δ is equal to the radius of the base cylinder of the involute and the angle of steepest descent β is related to the axial pitch distance P by the equation:

$$P = 2\pi\delta \tan \beta$$

If, therefore, the tooth surface to be

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tested has a shape specified by δ, β, the auxiliary surface will lie on a helix specified by $\delta, \frac{\beta}{2}$. For example, in the case of a spur gear in which $\beta=90°$ and the axial pitch distance is infinite, the auxiliary surface will have the same base cylinder, an angle of descent equal to 45° and an axial pitch distance equal to the circumference of the base cylinder.

In order to test simultaneously a number of teeth it is merely necessary to form the auxiliary surface with a similar number of surfaces so that it takes the form of a complete auxiliary gearlike surface.

One embodiment of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Fig. 1 shows diagrammatically a Michelson type interferometer adapted in accordance with the present invention, and

Fig. 2 is nominally a projection upon infinity at an angle of 60° to the axis of a spur gear surrounded by a female helical auxiliary reflector.

Referring to Fig. 1, a pinhole white-light source 1 and a condensing lens 2 provides a beam of light which is in part reflected from, and in part transmitted through, a dividing plate 3 to image the source at points a few inches beyond the dividing plate. At each of these image points may be located, if desired, small achromatic lens 4 and 5 respectively.

The part of the beam which is reflected passes through lens 4 into a combination comprising a Cassegrain telescope having a secondary hyperboloid 6 provided with an axial aperture 7, through which the beam passes, and a primary paraboloid 8. A gear 9 to be tested and an auxiliary reflector surface 10 are cascaded by means of the telescope from which the beam passes out through the aperture 7 through the dividing plate 3 to an observing objective 11.

The achromatic lenses 4 and 5 are of equal central thickness but of different focal power in order that the objective 11 may be focused simultaneously on the gear surface being tested and the flat 15. The use of these lenses obviates the necessity for a very small light source to minimise the difference in the off-axis transit time between the two combinations.

In Fig. 2 there is shown in detail the spur gear 9 surrounded by a 45° helical auxiliary reflector 10. In order to provide for separation of the errors in the gear 9 and the reflector 10 the gear 9 is mounted for rotation about its axis while the auxiliary reflector 10 is provided with four controls for aligning its axis to coincide with that of the gear. The reflector 10 is also capable of being raised or lowered.

In order to carry out a test on a gear, the latter is mounted in the interferometer. The auxiliary reflector 10 is then orientated by means of the aforesaid four controls until its axis coincides with the axis of the gear. The objective 11 is simultaneously focused on the gear surface and the flat 15 by means of the achromats 4 and 5 and the procedure thereafter follows the usual procedure for a Michelson interferometer.

It will be appreciated that with gear teeth having a pressure angle of less than 45° the roots of each tooth will be partly obscured by neighbouring teeth preventing complete examination.

It will also be appreciated that any irregularities of the surfaces of the gear and the auxiliary reflector as compared with a standard plane reflecting surface will be revealed by light fringes in the normal manner and suitable techniques involving relative rotation of the two surfaces will enable irregularities on either the tooth surface or auxiliary surface to be identified and such irregularities may be removed by polishing or other suitable methods in known manner.

The accuracy of the form of the individual teeth and rapidly changing errors in pitch will be detected by the method of testing of this invention and techniques may be devised whereby the entire periphery of any gear may be explored, assuming that a suitable auxiliary gearlike surface is available. Such technique combined with successive indexing of the gear with respect to the auxiliary gearlike surface would reveal separately accumulated pitch errors of both gears.

What we claim is:—

1. The method of testing the accuracy of profile surface of a straight- or helical-cut gear in which the gear is set up in a Michelson type interferometer in substitution for one of the two usual plane test surfaces and with its axis parallel to the optical axis, and the surface of the gear is viewed by reflection from an auxiliary surface which is itself of the same general shape as the gear profile surface and is so shaped and disposed as to produce a substantially plane image of the gear surface which may be compared with a standard, plane reference surface of the interferometer.

2. The method of testing the accuracy

of a gear as claimed in claim 1, in which both the auxiliary surface and the surface of the gear to be tested are shaped in accordance with the mathematical considerations set forth herein so that in plan every normal to one surface will coincide with a normal to the other surface.

3. In or for use in the testing of the accuracy of a surface of the gear by the method claimed in claim 1 or claim 2, an auxiliary gear-shaped reflecting surface constructed and arranged substantially as herein described and as illustrated in the accompanying drawings.

4. The method of testing the accuracy of surface of a straight- or helical-cut gear by interferometry substantially as herein described.

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PROVISIONAL SPECIFICATION

Improvements relating to the Testing of Gear Teeth

We, CECIL REGINALD BURCH, of 11, Percival Road, Clifton, Bristol, 8, in the County of Gloucester, and JAMES MORRISS BURCH, of 27, Elmgrove Road, Cotham, Bristol, 6, in the County of Gloucester, both subjects of the King of Great Britain, and METROPOLITAN-VICKERS ELECTRICAL COMPANY LIMITED, of St. Paul's Corner, 1—3, St. Paul's Churchyard, London, E.C.4, a British Company, do hereby declare this invention to be described in the following statement:—

In copending Patent Application No. 14,142 of 1949 there is described a method of testing the accuracy of the surface of a screw thread in which the surface as viewed by reflection or refraction from a special auxiliary surface is compared with a standard reference surface of an interferometer so that any departure of the screw surface from the desired figure will be revealed by the production of light fringe patterns. Conveniently such comparison may be effected by an adaptation of the Michelson interferometer in which the screw thread to be tested is arranged in substitution for one of the usual plane test surfaces with its axis parallel to the instrument axis and the surface of the thread is viewed by reflection from the auxiliary surface which is itself generally screw shaped in form and is so shaped and arranged that the surface of the screw as seen by the instrument appears substantially plane and may thus be compared with the other plane test surface of the interferometer.

The present invention is concerned with an adaptation of the above method to testing the accuracy of the shape of gear teeth which are of involute form.

In the method of the present invention, a gear to be tested, which may have either straight or helical cut teeth, is mounted with its axis parallel to the instrument axis and the tooth surface is seen by reflection from a coaxial auxiliary surface which is so shaped and disposed as to form a plane image of the tooth surface. By a "plane image" is here meant not necessarily an image stigmatic in the Gaussian sense but an image characterised by that the transit time measured along a principal ray or a ray paraxial thereto is that which it would be were the combination replaced by a plane surface.

The formation of such a plane image requires that every ray along the axis after incidence upon the auxiliary surface is reflected along a normal to the tooth surface, and this further requires that for every pair of corresponding points on the auxiliary surface and the tooth surface the angles of steepest descent β must be half at the former surface what it is at the latter and that the normals must coincide as viewed in plan, or, in other words, must both miss the axis by the same skew distance δ.

Now the geometry of the involute curve implies that both δ and β are constant over the whole tooth surface of any spur or helical gear. The skew distance δ is equal to the radius of the base cylinder of the involute and the angle of steepest descent β is related to the axial pitch distance P by the equation:

$$P = 2\pi\delta \tan \beta$$

If, therefore, the tooth surface to be tested has a shape specified by δ, β, the auxiliary surface will lie on a helix specified by δ, $\frac{\beta}{2}$. For example, in the case case of a spur gear in which $\beta = 90°$ and the axial pitch distance is infinite, the auxiliary surface will have the same base cylinder, an angle of descent equal

to 45° and an axial pitch distance equal to the circumference of the base cylinder.

If it is desired to test simultaneously a number of teeth it is merely necessary to form the auxiliary surface with a similar number of surfaces so that it takes the form of a complete auxiliary gearlike surface.

It will be appreciated that any irregularities of the two surfaces as compared with a standard plane reflecting surface will be revealed by light fringes in the normal manner and suitable techniques involving relative rotation of the two surfaces will enable irregularities on either the tooth surface or auxiliary surface to be identified and such irregularities may be removed by polishing or other suitable methods in known manner.

The accuracy of the form of the individual teeth and rapidly changing errors in pitch will be detected by the method of testing of this invention and techniques may be devised whereby the entire periphery of any gear may be explored, assuming that a suitable auxiliary gearlike surface is available. Such technique combined with successive indexing of the gear with respect to the auxiliary gearlike surface would reveal separately accumulated pitch errors of both gears.

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709,431 COMPLETE SPECIFICATION
2 SHEETS
This drawing is a reproduction of the Original on a reduced scale.
SHEET 1

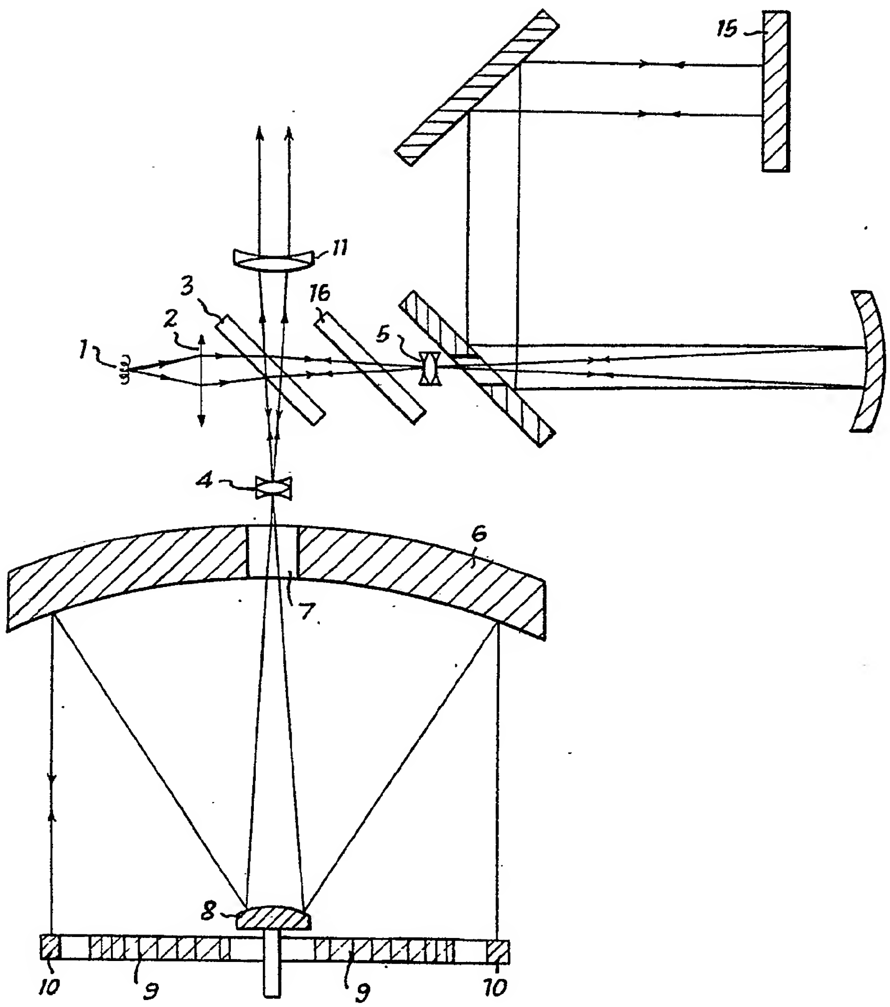

FIG.1.

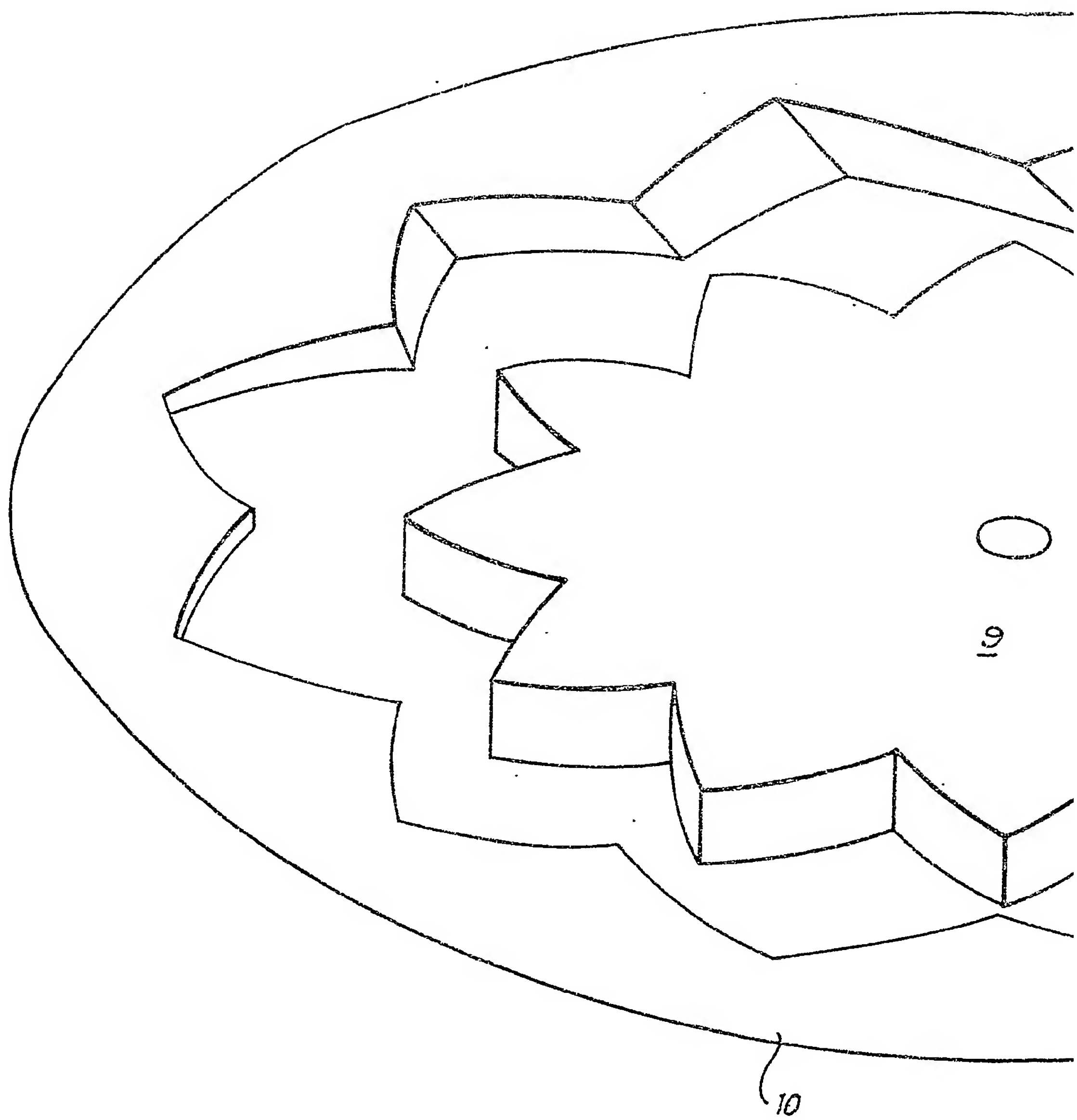

FIG.2.

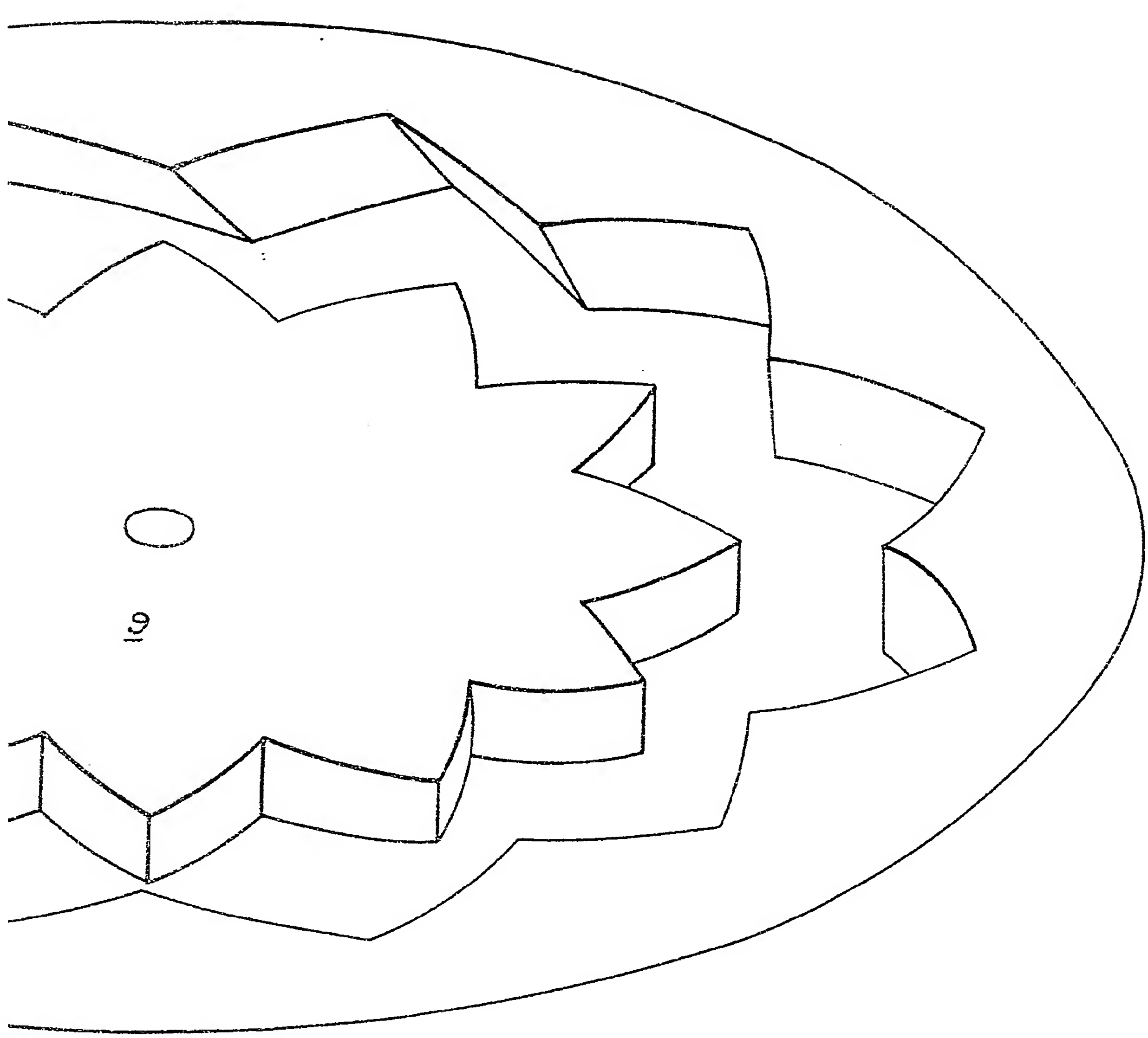

FIG. 2.

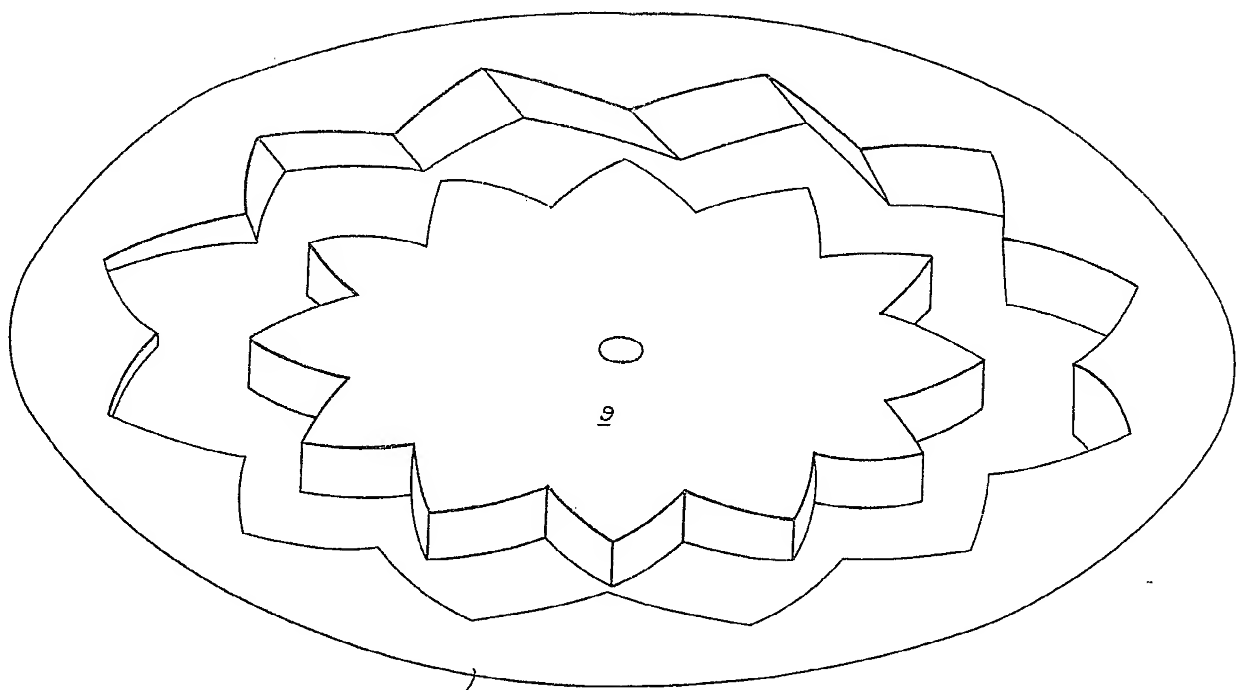

FIG.2.